Update on Stabilization Studies

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Stabilization Projects

- Inertial Vibration Stabilization
  - Use feedback from inertial sensors to control final doublet positions.
- FONT (Feedback on Nanosecond Timescales)
  - Test intra-train fast IP deflection feedback in the NLCTA

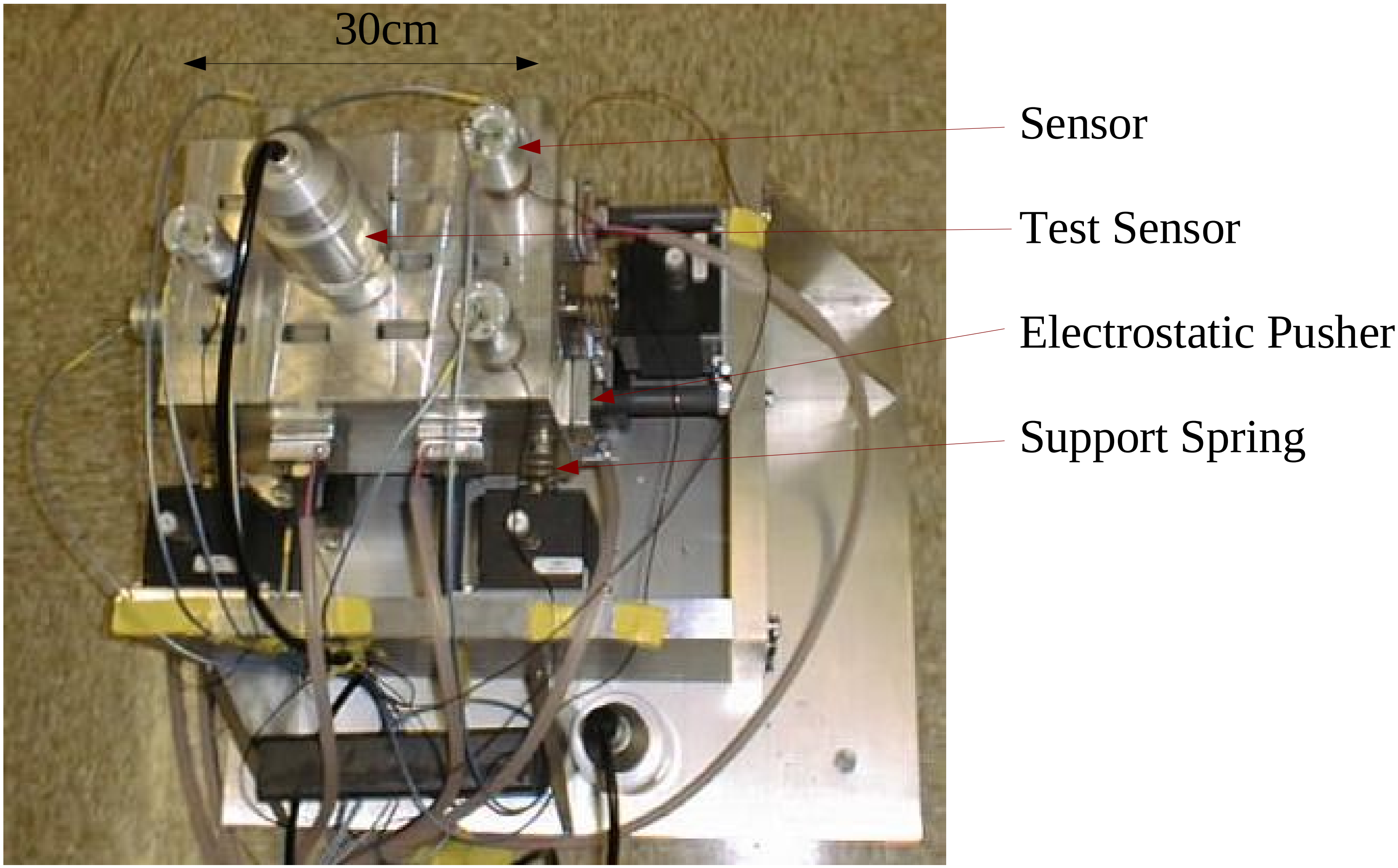
Not covered in this talk

- Beam Simulations – (PTs talk)
- IP Girder Test – Tom Markiewicz talk (Next)
- Optical Anchor – Work in progress at UBC
- RF girder test – Work at FNAL (later talk)

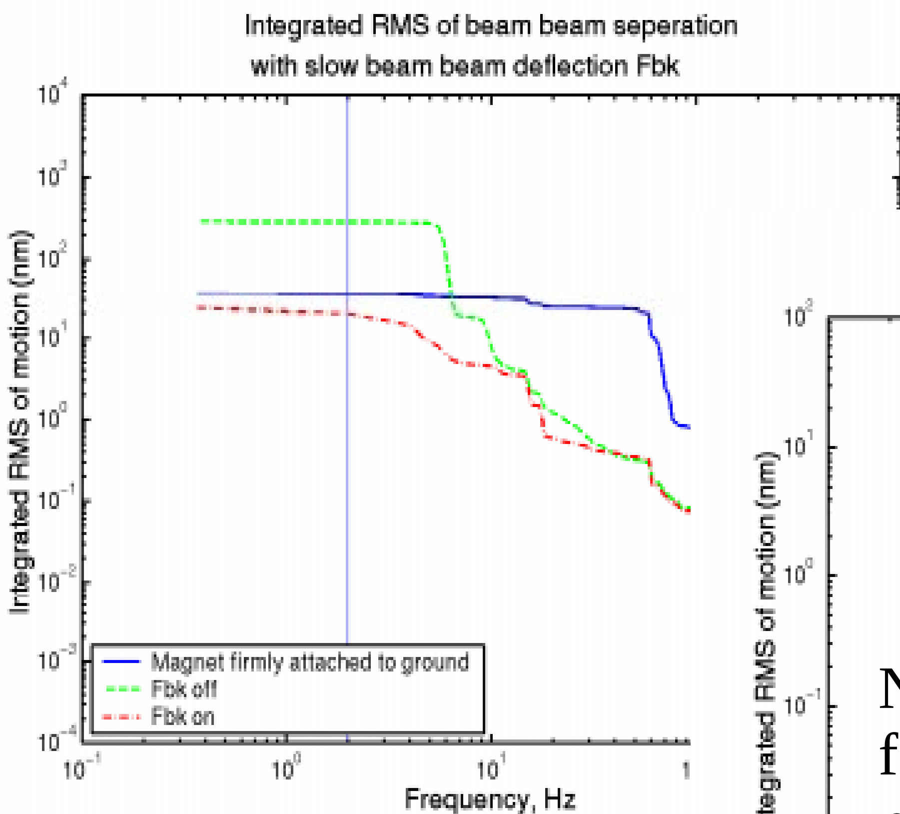
Inertial Stabilization System Status

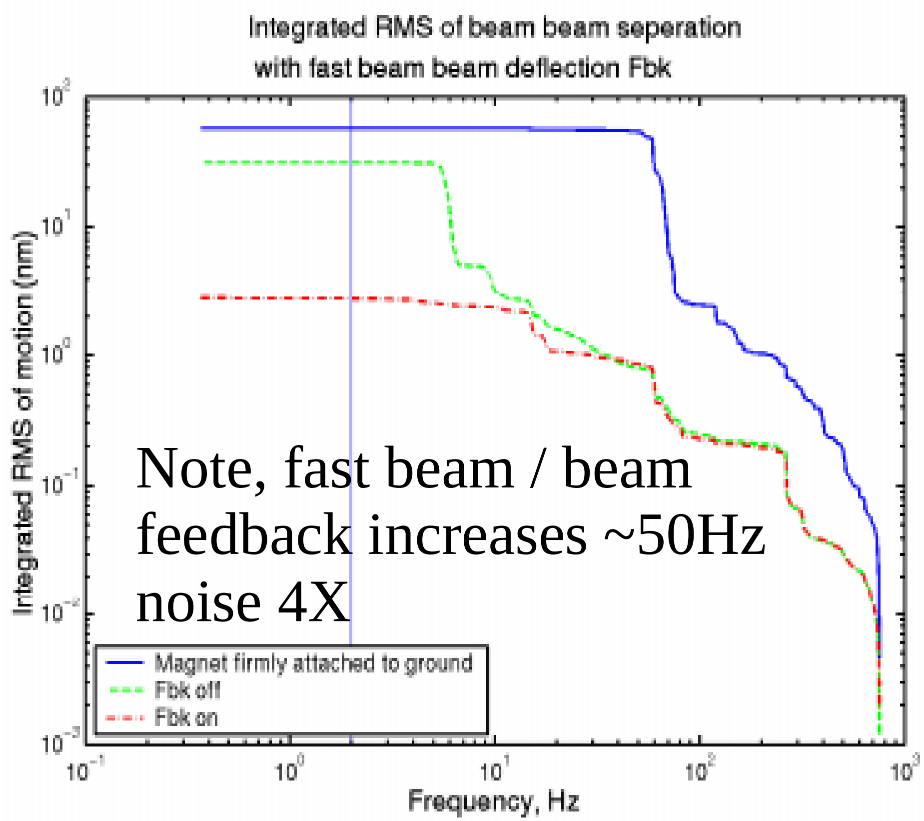
- Prototype System with commercial sensors complete
  - 6 degree of freedom system with few Hz resonant frequencies
  - Commercial geophone sensors (HS-1)
  - Electrostatic pushers
  - DSP based feedback system operating at ~1KHz
- Recent Updates
  - Anti-Alias filter (300Hz, 1 pole) added to reduce noise.
  - Software pre-averaging increased to ~X20
- Additional improvement requires low noise sensors.

Inertial Stabilization Test System



System Performance





Note, fast beam / beam feedback increases ~50Hz noise 4X

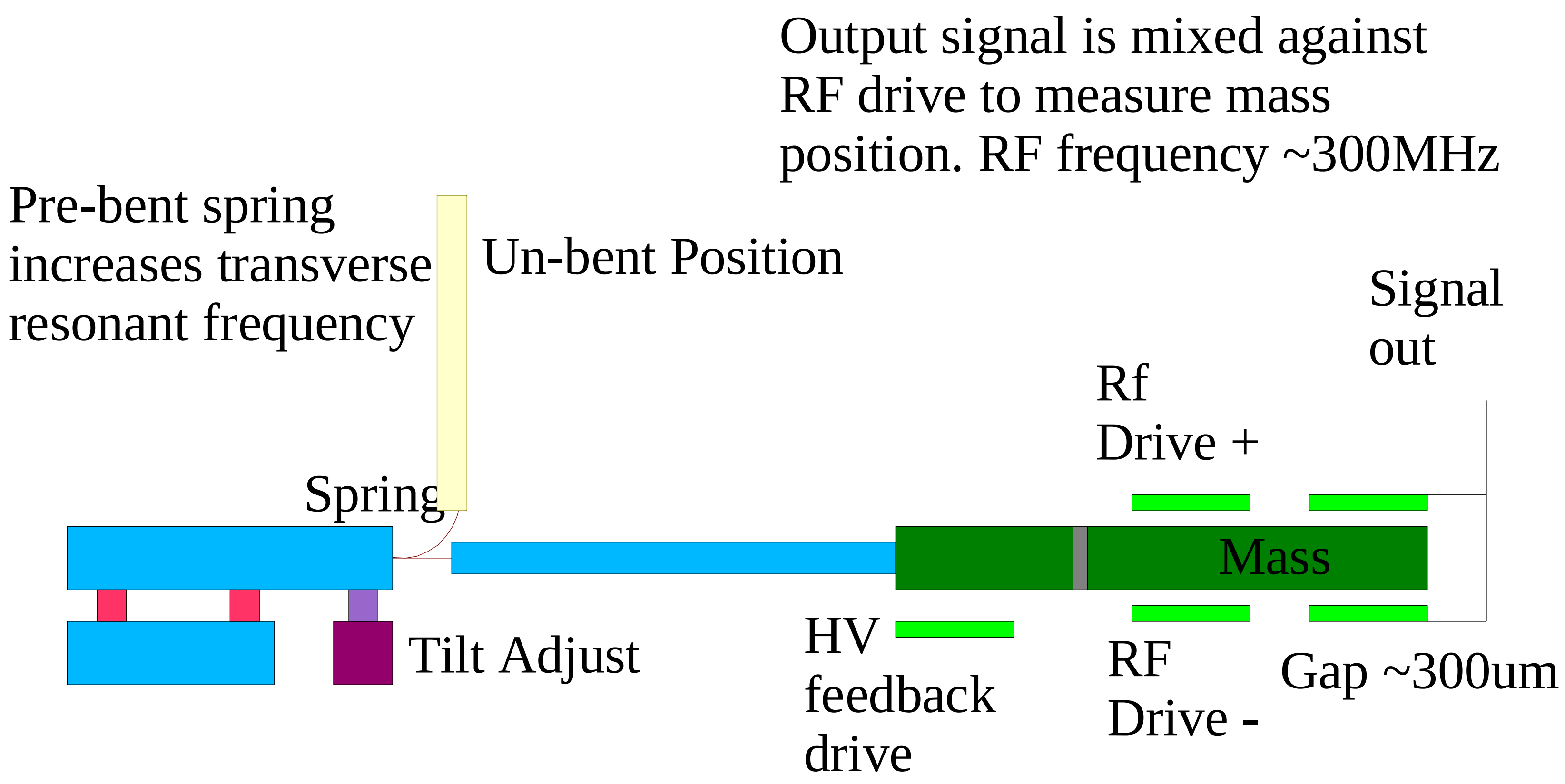
System Performance Status

- System tested in “noisy” lab. (Comparable to DESY site), and with noisy sensors.
- Simulated beam-beam feedback applied to measured motion is used to evaluate performace of system
  - (Accelerometers do not read to DC)
  - Performance depends on Beam feedback model
- Ground motion correlations ignored
- Feedback and support improves performance relative to “ideal” rigid support.

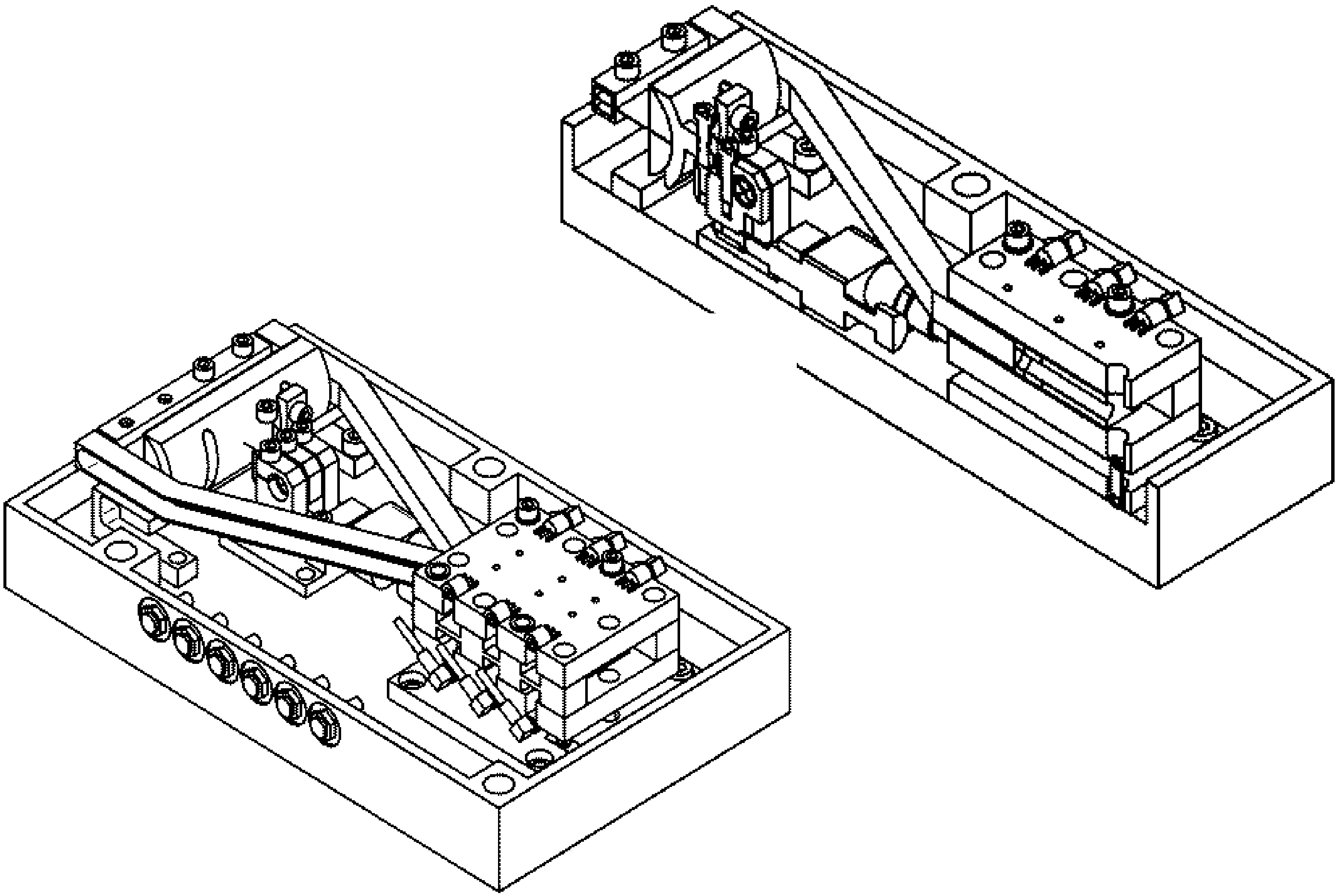
Inertial Sensor Development

- Noise from “HS-1” compact geophones dominates system noise.
  - Geophones are velocity sensors – noise grows as f^{-3} Noise is ~1000 nanometers integrated to 0.1 Hz
  - Low noise sensors (STS-2) can measure 0.5nm integrated noise down to 0.1 Hz, but are large and magnetically sensitive.
- We are developing a compact non-magnetic capacitive sensor
  - THEORETICAL noise is ~0.1nm integrated noise to 0.1Hz. (Expect real noise to be ~1nm to 0.1Hz)

Sensor Design Concept

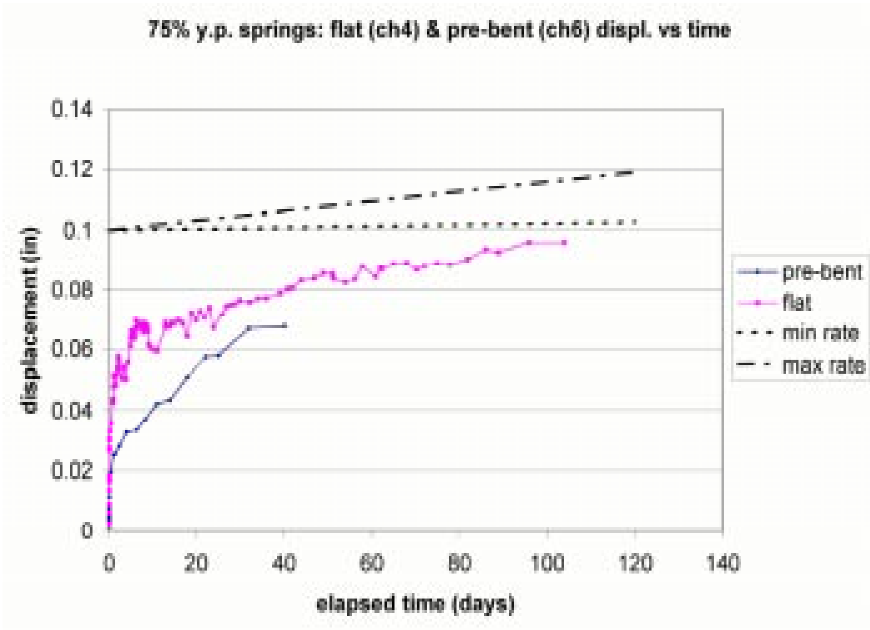


Sensor Detailed Design



Spring Creep Data

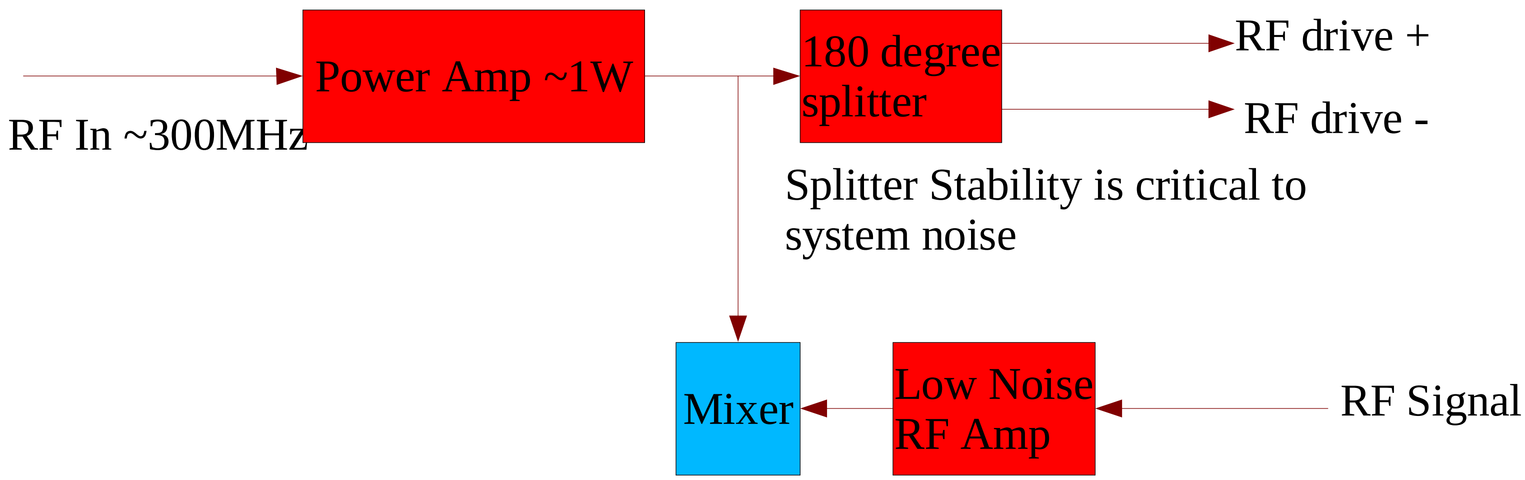
- Use of “pre-bent” spring greatly increases second mode frequency
- System designed for 10 year creep life (with motor offset adjust)
- Creep measurements match existing data



System Mechanical Parameters

- Parameters derived from ANSYS simulation
- Fundimental Frequency = 1.47Hz, 59gm mass.
- Next mode frequencies 96.6 Hz Roll
  - Can be increased by changing “Y” beam from Al to Be.
  - Probably not seen by position sensor
- Next higher frequency 185 Hz
  - Can be increased by changing “Y” beam to Be
- Mechanical Q expected to be a few hundred
- Corresponding thermal noise is $1.5\text{x}10^{-10}\text{M/s}^2/\text{Hz}^{1/2}$

Electronic Readout

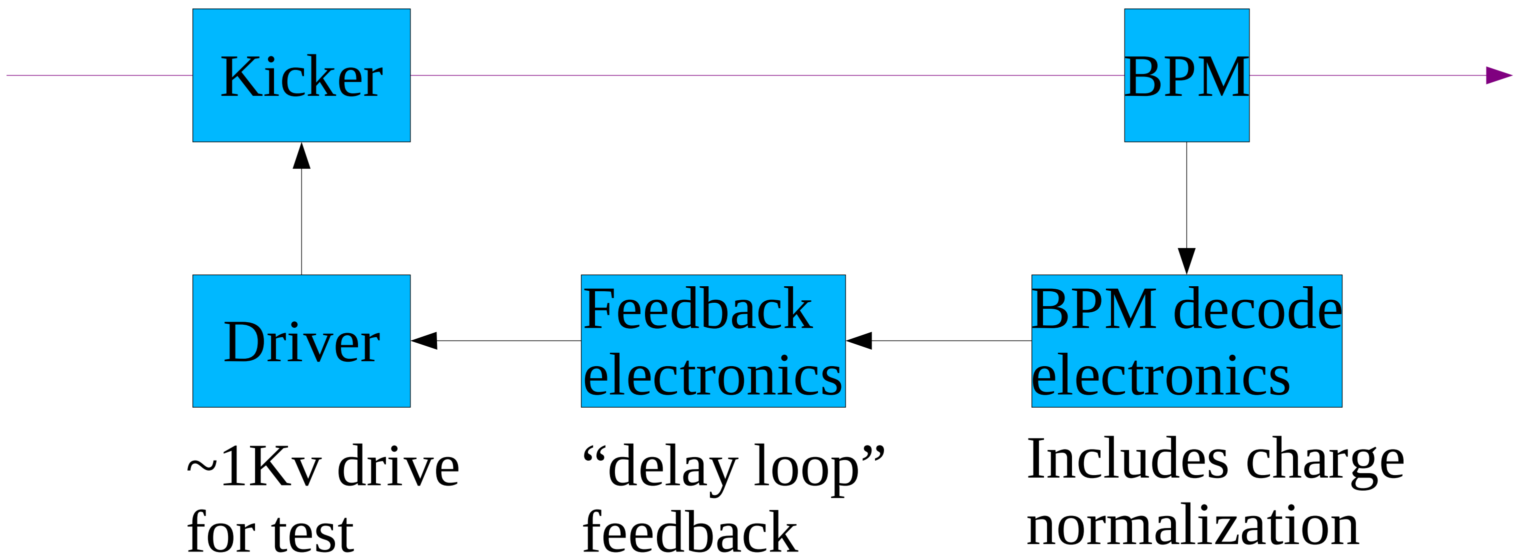


Theoretical electronic noise (300um gap) = $\sim 10^{-12}$ M/Hz$^{1/2}$
Corresponds to $\sim 10^{-10}$M/s^2/Hz$^{1/2}$.acceleration noise.
Splitter ratio variations will dominate low frequency noise

Feedback On Nanosecond Timescales

- Use Beam / Beam deflection within the 300ns bunch train
- Same concept as TESLA system, but must operate on much shorter timescales
- “Belt and Suspenders” approach: NLC is designed to operate without intra-train feedback, but it can be added without interfering with other systems.
- Test underway at NLCTA by group from Oxford Univ.

Basic FONT Block Diagram



Total loop delay (without cable and beam delay) expected to be ~10ns.

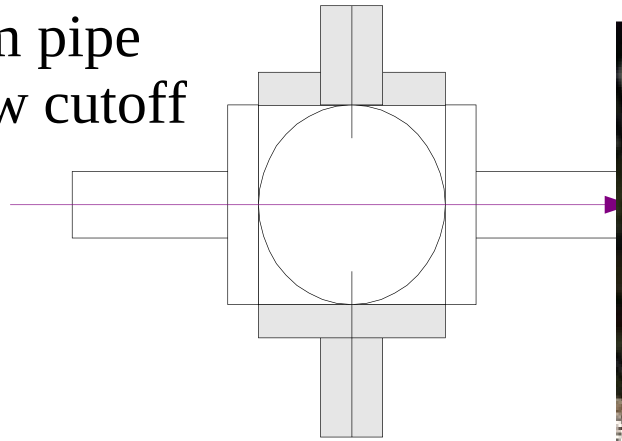
System will correct an initial beam offset within the ~100ns NLCTA pulse

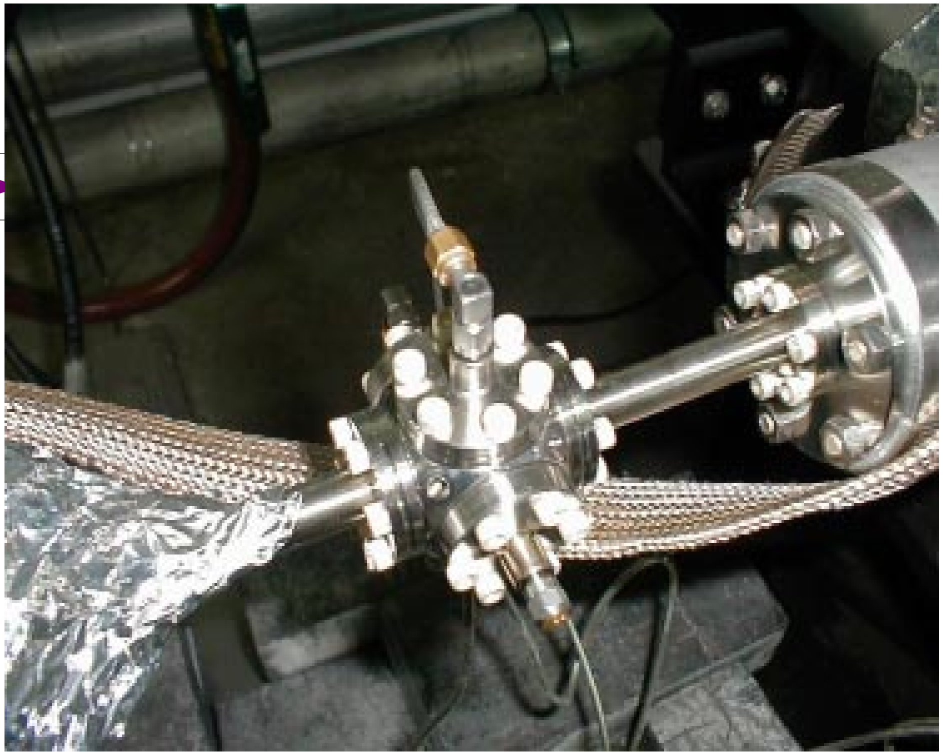
FONT Components

- Kicker: Existing SLAC kicker used.
- BPM: Must provide time resolved measurement on a beam bunched at X-band (11.424 Ghz)
  - Use “resonant button BPM
- Decode electronics: Down mix X-band signal to DC
  - Must divide out beam intensity signal
- Feedback electronics: Delay line design
  - This is actually the easy part.
- Amplifier: Use planar triode – expect 1KV, 5ns
  - Being developed at Oxford

Resonant Button BPM

Beam pipe
below cutoff

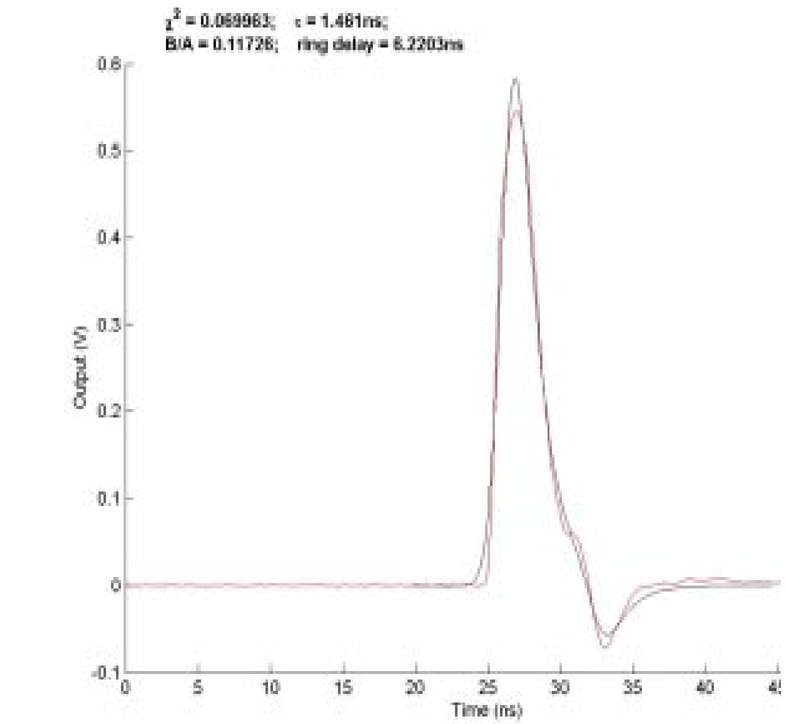




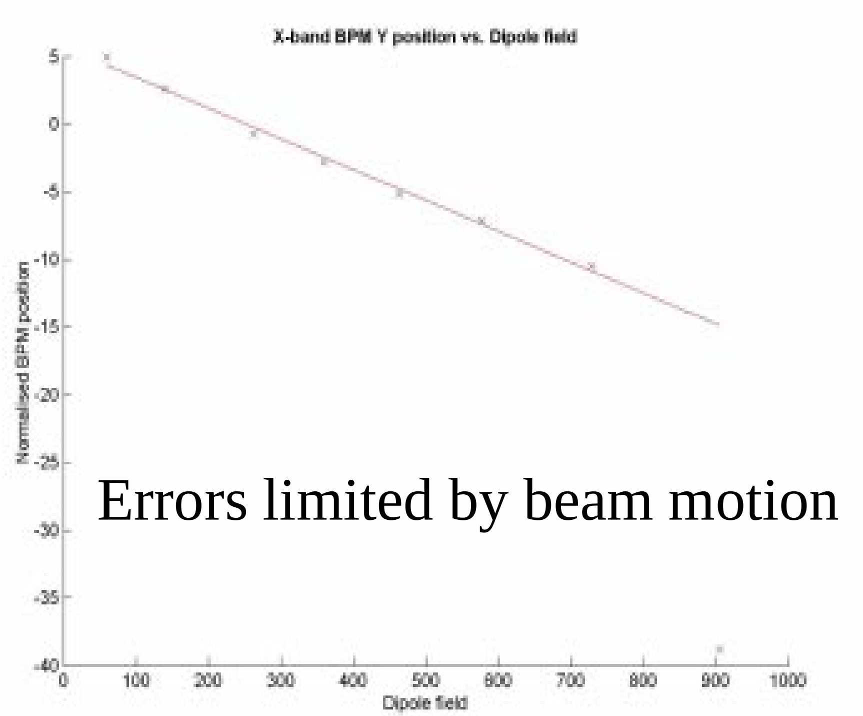
SMA feed through
trimmed to resonate
at 11.424 Ghz

Beam coupling impedance ~40 Ohms

BPM Tests



Noise not measured, but expected to be a few microns



Errors limited by beam motion

Time constant is 1.4nsec, with a 6ns delayed ring (due to RF reflection).

Status of other FONT components

- BPM decode electronics normalization
  - Arbitrary function generator produces 1/x of the current measured on previous pulse. Multiply this with the raw (top – bottom) signal.
  - Second order correction option for pulse to pulse current waveform variations
    - Basically create next term in Taylor series with analog multipliers.
- Feedback electronics: Simple linear circuit.
- Kicker driver: Uses Y690 Planar triodes
  - Works in simulation
  - Construction underway

Overall Stabilization Status

- Hope to construct in a quiet site
  - Should be sufficient for all magnets except final doublet.
- Use vibration feedback (inertial and / or optical anchor) to control final doublet.
  - Hope to use “Aggressive” beam / beam feedback
  - Design around use of “non-aggressive” feedback
  - Need new inertial sensors.
- Use intra-train feedback to fix any remaining problems: Testing concept with FONT project.